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Evaluating Median Nerve Cross Sectional Area via Ultrasound; A Comparative Study between Sonographers and Non-Sonographers

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ABSTRACT

Background: Sonographers are at an increased risk of developing median nerve abnormalities due to repetitive hand movements and prolonged occupational strain. This study evaluate the median nerve cross-sectional area, fascicular pattern, shape, and mobility among sonographers and non-sonographers using ultrasonography. **Objective:** To evaluate median nerve cross-sectional area (CSA) via Ultrasound between sonographers and non-sonographers. **Methodology:** This was a cross-sectional analytical study conducted over a period of four months, from November 04, 2024 March 03, 2025 at the Radiology Department of Services Hospital, Lahore. The study included 60 participants, and data was analyzed using the Statistical Package for the Social Sciences (SPSS). **Results:** The majority of participants were male (60%), while 40% were female. Right-hand dominance was observed in 56.7% of participants. The most frequent years of experience was 16 years (11.7%). The fascicular pattern assessment showed that 66.7% of participants had an intact pattern in the right hand, whereas the left hand showed a higher proportion of disrupted patterns (56.7%). Regarding nerve shape, a flattened median nerve was found in 48.3% of participants for the right hand and 50% for the left hand. Nerve mobility evaluation indicated that 36.7% of participants had normal mobility in the right hand, while 33.3% showed nerve entrapment. In the left hand, nerve entrapment was more common (43.3%), followed by normal mobility (36.7%). Gender-based analysis revealed a trend toward a higher prevalence of flattened nerves in females compared to males, though statistical significance was not reached ($p = 0.073$). No significant association was found between gender and nerve mobility ($p = 0.375$). **Conclusion:** This study found a higher prevalence of intact fascicular patterns and normal nerve mobility in the right hand, while the left hand showed more disrupted patterns and nerve entrapment. Flattened median nerves were common in both hands, slightly more so in females, though not statistically significant. No significant link was found between gender and nerve mobility. Overall, the left hand appeared more prone to structural and functional nerve changes.

INTRODUCTION

The median nerve, which travels through the carpal tunnel in the wrist, is particularly vulnerable to repetitive strain. Compression or irritation of this nerve can result in carpal tunnel syndrome (CTS), a condition characterized by pain, numbness, and tingling in the hand and fingers. If not addressed, CTS can result in a loss of strength and function, greatly impacting an individual's ability to execute intricate motor activities.[1] In addition to its imaging functions, ultrasound imaging serves as a reliable technique for determining the median nerve's health status. In particular, the cross sectional area (cross-sectional area) of a median nerve ultrasound is one of the gold standards for diagnosing CTS.[2] This method is simple and non-invasive, enabling easy and real-time assessment of changes to the nerve, which is beneficial for early detection of health-related risks among sonographers.[3] Carpal tunnel syndrome (CTS) is a major concern for occupational health among sonographers. Research suggests that up to 80% of sonographers are likely to have some level of work-related musculoskeletal discomfort, and CTS is among the frequently registered disorders. Studies show that female sonographers, who make up the majority of the workforce, are especially susceptible because of differing the wrist skeletal anatomy and hormonal factors.[4] Even though CTS is common among this group, it tends to be underdiagnosed. Most sonographers postpone getting assistance because of career-related fears or unintentionally dismissing symptoms. This waiting period until treatment has been reached may contribute to chronic illnesses, permanent functional incapacity, and early retirement from work.[5] The

increased utilization of diagnostic imaging has heightened the workload of sonographers, thereby increasing their occupational health risks. Although the issues with CTS are frequently noted in the literature, there is scant research evaluating the structural changes of the median nerve, particularly within the context of ultrasound imaging. In the absence of early diagnostic measures and treatment, sonographers are likely to experience advanced and disabling stages of CTS that pose considerable challenges to their physical wellbeing and professional life.[6] Monitoring the relationship between occupational risk factors and median nerve structure modifications involving cross sectional area remains critical in addressing the problem. Nonetheless, there is a gap in the literature that examines the use of ultrasonography to analyze the median nerve cross section area of active and practicing sonographers for the purpose of formulating evidence-based preventive measures.[7] This research aims to fill in the gap by employing ultrasound imaging techniques to analyze the position of the median nerve cross sectional area to detect early signs of CTS within the sonography population. The results will significantly contribute towards the field of occupational health for this population group. As stated, preventive measures such as ergonomic alterations, routine checkups, and educational activities are guided towards specific objectives and have the potential to be developed through focused research aimed at early detection and intervention.[8] The aim of this study is to determine the role of ultrasound examinations in evaluating the risk for carpal tunnel syndrome (CTS) in sonographers relative to non-sonographers, by comparing their results with those of non-sonographers. This will further demonstrate why healthcare institutions need to take active steps towards protecting the health of their sonographers. Actively managing CTS as an occupational disease with appropriate interventions not only elevates the life quality of industrial sonographers but also guarantees longevity in performance within diagnostic medical imaging.

MATERIALS AND METHODS

A comparative cross-sectional study was done in Services Hospital, Lahore. The study included two study groups, one of sonographers and other of non-sonographers. For sonographers, certified sonographers were included with at least 1 year of experience and performing ultrasound for a minimum of 20 hours per week. For non-sonographers, individuals of the age range 25-60 years were included. Sonographers with a prior diagnosis of carpal tunnel syndrome or other neuropathies were excluded. Individuals with a history of hand or wrist trauma, past surgery, systemic conditions affecting nerves like diabetes mellitus or arthritis were also excluded. Pregnant individuals were not included in the study. The study population comprised of 60 participants, 30 in Sonographers group and 30 in Non-Sonographers group. Data was obtained through non-probability sampling technique, with informed consent obtained from all the participants. Data analysis was performed using the Statistical Package for the Social Sciences (SPSS), version 23 software.

RESULTS

The study analyzed various sonographic findings related to the median nerve, incorporating demographic and experience-related variables. The majority of participants were male (60%) and right-hand dominant (56.7%). Experience levels ranged from 1 to 20 years, with 16 years being the most common (11.7%). Fascicular patterns varied between hands, with an intact pattern being more common in the right hand (66.7%) but a disrupted pattern prevailing in the left (56.7%). The median nerve shape was nearly evenly distributed in both hands, though males were more likely to have a normal shape in the right hand (61.1%), while females more commonly exhibited a flattened shape (62.5%). Nerve mobility findings showed that normal mobility was most frequent in the right hand (36.7%), while entrapment was more common in the left (43.3%). A crosstab analysis between gender and sonographer status revealed a balanced distribution, with 50% of females and 41.7% of males being sonographers. No significant gender differences were observed in right-hand nerve mobility.

Table 1

This table presents the gender distribution of the participants. The majority of participants were male (60%), while females comprised (40%) of the total sample

Gender			
		Frequency	Percent
Valid	Female	24	40.0
	Male	36	60.0
	Total	60	100.0

Table 2

This table shows the dominant hand distribution among participants. A greater proportion (56.7%) were right-hand dominant, while (43.3%) were left-hand dominant.

Dominant Hand			
		Frequency	Percent
Valid	Left	26	43.3
	Right	34	56.7
	Total	60	100.0

Table 3

The distribution of participants' years of experience varies widely, ranging from 1 to 20 years. The most common experience level was 16 years (11.7%), followed by 9 years (10.0%). Other frequently observed experience levels include 5 years (8.3%) and 7 years (8.3%).

Years of Experience		
	Frequency	Percent
1	4	6.7
2	3	5.0

3	1	1.7
4	3	5.0
5	5	8.3
6	2	3.3
7	5	8.3
8	2	3.3
9	6	10.0
10	4	6.7
11	1	1.7
12	3	5.0
13	2	3.3
15	3	5.0
16	7	11.7
17	3	5.0
18	3	5.0
19	1	1.7
20	2	3.3
Total	60	100.0

Table 4

This table presents the distribution of the fascicular pattern of the median nerve in both the right and left hands among participants. In the right hand, the majority (66.7%) exhibited an intact fascicular pattern, while (33.3%) had a disrupted pattern. Conversely, in the left hand, a disrupted fascicular pattern was more prevalent (56.7%) compared to an intact pattern (43.3%).

Fascicular Pattern	Right Hand Frequency (%)	Left Hand Frequency (%)
Disrupted	20 (33.3%)	34 (56.7%)
Intact	40 (66.7%)	26 (43.3%)
Total	60 (100.0%)	60 (100.0%)

Figure 1

Pie chart showing fascicular pattern frequency distribution in both hands. Median Nerve Shape Distribution in Right and Left Hands

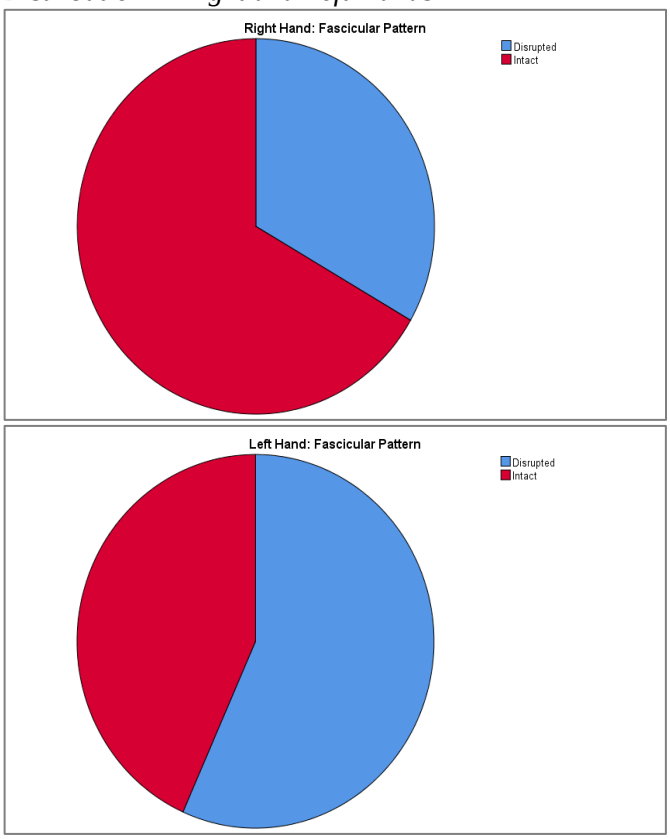


Table 5. This table presents the distribution of the median nerve shape in both the right and left hands among participants. In the right hand, the majority of participants (51.7%) had a normal median nerve shape, while 48.3% exhibited a flattened shape. In contrast, the left hand showed an equal distribution, with 50% having a normal shape and 50% showing a flattened appearance.

Median Nerve Shape	Right Hand Frequency (%)	Left Hand Frequency (%)
Flattened	29 (48.3%)	30 (50.0%)
Normal	31 (51.7%)	30 (50.0%)
Total	60 (100.0%)	60 (100.0%)

Figure 2

Showing Median Nerve Mobility in Right and Left Hands

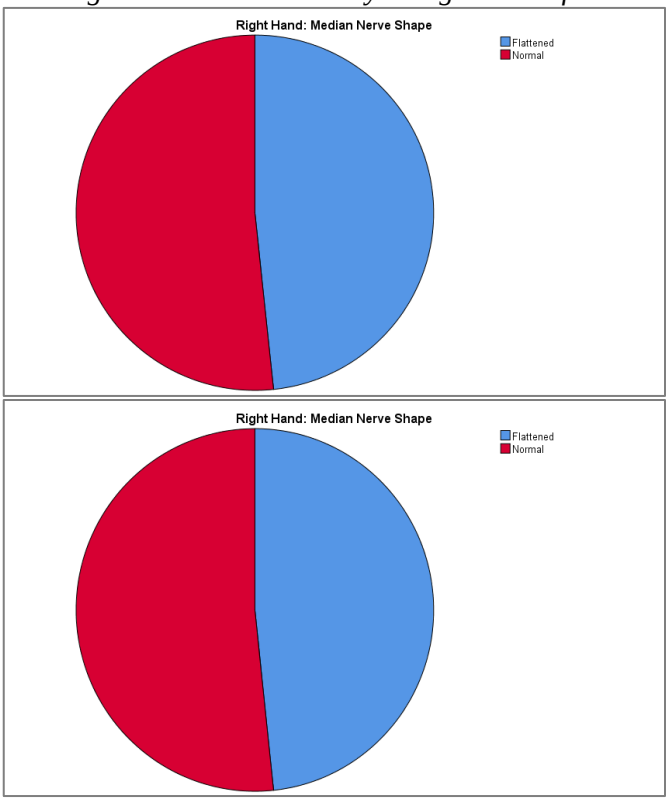


Table 6

This table illustrates the distribution of median nerve mobility in both the right and left hands among participants. In the right hand, normal nerve mobility was the most common finding (36.7%), followed closely by nerve entrapment (33.3%) and reduced mobility (30.0%). In the left hand, the most prevalent condition was nerve entrapment (43.3%), while normal mobility remained consistent with the right hand (36.7%). Reduced mobility was less common in the left hand (20.0%) compared to the right hand (30.0%).

Nerve Mobility	Right Hand Frequency (%)	Left Hand Frequency (%)
Entrapped	20 (33.3%)	26 (43.3%)
Normal	22 (36.7%)	22 (36.7%)
Reduced	18 (30.0%)	12 (20.0%)
Total	60 (100.0%)	60 (100.0%)

Table 7

The distribution of sonographers and non-sonographers was examined based on gender. Among female participants, 62.5% were sonographers, while 37.5% were non-sonographers. In contrast, among male participants, 41.7% were sonographers, and 58.3% were non-sonographers. The chi-square test ($\chi^2 = 2.500$, $p = 0.114$) indicated no statistically significant association between gender and sonographer status. This suggests that the proportion of sonographers is relatively balanced across genders, with no clear evidence that one gender is more likely to pursue a career in sonography than the other.

Crosstab

Count

		Sonographer		Total
		Non Sonographer	Sonographer	
Gender	Female	9	15	24
	Male	21	15	36
Total		30	30	60

Table 8

The relationship between gender and the median nerve shape in the right hand was analyzed. The results showed that a higher proportion of females (62.5%) exhibited a flattened median nerve shape compared to 38.9% of males. Conversely, a normal nerve shape was more common among males (61.1%) than females (37.5%). The chi-square test ($\chi^2 = 3.215$, $p = 0.073$) approached statistical significance, suggesting a possible trend where females may be more prone to having a flattened median nerve.

Crosstab

Count

		Right Hand: Median Nerve Shape		Total
		Flattened	Normal	
Gender	Female	15	9	24
	Male	14	22	36
Total		29	31	60

Gender * Right Hand: Nerve Mobility

Table 9

The study also assessed the relationship between gender and nerve mobility in the right hand. Among females, 41.7% exhibited nerve entrapment, 37.5% had normal mobility, and 20.8% had reduced mobility. In comparison, among males, 27.8% had entrapped nerves, 36.1% had normal mobility, and 36.1% had reduced mobility. The chi-square test ($\chi^2 = 1.961$, $p = 0.375$) revealed no significant relationship between gender and nerve mobility.

Crosstab

Count

		Right Hand: Nerve Mobility			Total
		Entrapped	Normal	Reduced	
Gender	Female	10	9	5	24
	Male	10	13	13	36
Total		20	22	18	60

Gender * Right Hand: Median Nerve Cross-Sectional Area mm

Table 10

The cross tabulation between gender and the median nerve cross-sectional area for the right hand shows that both male and female participants have a range of nerve sizes from 7mm to 13mm. However, males tend to have slightly larger nerve sizes compared to females. The chi-square test result ($\chi^2 = 3.524$, $df = 7$, $p = 0.833$) indicates that there is no statistically significant association between gender and the median nerve size in the right hand. This suggests that gender does not play a crucial role in determining the median nerve cross-sectional area for the right hand in this sample.

Crosstab

Count

		Right Hand: Median Nerve Cross-Sectional Area mm								
		7	8	9	10	11	12	13	14	
Gender	Female	4	3	4	4	3	1	3	2	24
	Male	5	1	7	5	7	4	4	3	36
		9	4	11	9	10	5	7	5	60

Gender * Left Hand: Median Nerve Cross-Sectional Area mm

Table 11

A similar analysis was performed for the left-hand median nerve cross-sectional area concerning gender. The distribution of sizes is comparable between males and females, with some variations in frequency at different size levels. The chi-square test result ($\chi^2 = 9.481$, $df = 7$, $p = 0.220$) suggests that there is no significant relationship between gender and the median nerve cross-sectional area in the left hand. These findings indicate that gender does not significantly affect the left-hand median nerve size, consistent with the results for the right hand

Crosstab

Count

		Left Hand: Median Nerve Cross-Sectional Area mm								
		7	8	9	10	11	12	13	14	
Gender	Female	4	1	4	3	6	2	3	1	24
	Male	6	7	2	2	5	7	2	5	36
Total		10	8	6	5	11	9	5	6	60

Years of Experience * Right Hand: Median Nerve Cross-Sectional Area mm

Table 12

The association between years of experience and the right-hand median nerve cross-sectional area was examined using a cross tabulation. The distribution of nerve sizes across different experience levels shows variation, but no clear trend is observed. The chi-square test result ($\chi^2 = 135.497$, $df = 126$, $p = 0.266$) indicates no statistically significant association. This suggests that years of experience as a sonographer do not have a notable impact on the median nerve size in the right hand.

Years of Experience	7mm	8mm	9mm	10mm	11mm	12mm	13mm	14mm	Total
1	0	0	0	1	2	0	1	0	4
2	0	2	0	0	1	0	0	0	3
3	0	0	1	0	0	0	0	0	1
4	0	0	0	0	1	0	1	1	3
5	1	0	1	1	2	0	0	0	5
6	0	0	1	0	0	0	1	0	2
7	0	0	3	0	0	0	0	2	5
8	0	0	0	0	1	1	0	0	2
9	2	1	1	0	0	1	1	0	6
10	3	0	1	0	0	0	0	0	4
11	0	0	1	0	0	0	0	0	1
12	0	0	0	1	0	0	1	1	3
13	1	0	1	0	0	0	0	0	2
15	0	0	0	2	0	1	0	0	3
16	1	1	1	1	1	1	1	0	7
17	0	0	0	2	0	1	0	0	3
18	0	0	0	1	1	0	1	0	3
19	1	0	0	0	0	0	0	0	1
20	0	0	0	0	1	0	0	1	2
Total	**9**	**4**	**11**	**9**	**10**	**5**	**7**	**5**	**60**

Crosstab: Years of Experience vs. Left-Hand Median Nerve Cross-Sectional Area

Table 13

For the left hand, the relationship between years of experience and the median nerve cross-sectional area appears different. While the chi-square test does not indicate a significant categorical association, the correlation analysis shows a Pearson's r of -0.400 ($p = 0.002$) and a Spearman correlation of -0.423 ($p = 0.001$), both of which are statistically significant. This indicates a moderate negative correlation, meaning that as years of experience increase, the median nerve cross-sectional area in the left hand tends to decrease. This could suggest that prolonged use of the left hand in sonographic practice may lead to adaptive or compressive changes in the median nerve.

Years of Experience	7mm	8mm	9mm	10mm	11mm	12mm	13mm	14mm	Total
1	0	0	0	1	0	1	0	2	4
2	0	0	0	0	1	2	0	0	3
3	0	0	1	0	0	0	0	0	1
4	0	0	0	2	1	0	0	0	3
5	0	0	1	1	0	2	1	0	5
6	0	1	0	0	0	1	0	0	2
7	0	0	0	0	2	0	0	3	5
8	0	0	0	0	1	1	0	0	2
9	1	2	1	0	0	1	1	0	6
10	2	1	0	0	1	0	0	0	4
11	0	0	0	0	1	0	0	0	1
12	1	0	1	0	0	0	1	0	3
13	2	0	0	0	0	0	0	0	2
15	0	0	0	0	1	0	1	1	3
16	0	2	1	0	2	1	1	0	7
17	2	0	0	0	1	0	0	0	3
18	1	1	0	1	0	0	0	0	3
19	0	0	1	0	0	0	0	0	1
20	1	1	0	0	0	0	0	0	2
Total	**10**	**8**	**6**	**5**	**11**	**9**	**5**	**6**	**60**

Figure 3

This ultrasound image shows an enlarged median nerve with a hypoechoic appearance and loss of the normal fascicular pattern. The cross-sectional area (CSA) of the nerve is increased measures 9.9 mm3.

Figure 4

This ultrasound image shows a broad lines size median nerve with a hypoechoic appearance and loss of the normal fascicular pattern. The cross-sectional area (CSA) of the nerve is increased measures 8.4 mm3.

Figure 5

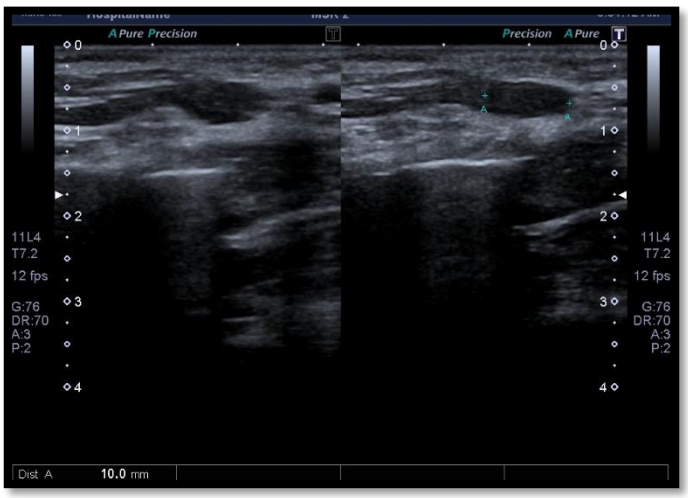
This ultrasound image shows an enlarged median nerve with a hypoechoic appearance and loss of the normal fascicular pattern. The cross-sectional area (CSA) of the nerve is increased measures 9.2 mm3.

Figure 6

This ultrasound image shows an normal median nerve. The cross-sectional area (CSA) of the nerve is increased measures 7.9 mm3.

Figure 7

This ultrasound image shows an enlarged median nerve with a hypoechoic appearance and loss of the normal fascicular pattern. The cross-sectional area (CSA) of the nerve is increased measures 10 mm3.



DISCUSSION

This study aimed to evaluate the median nerve cross-sectional area (CSA) through ultrasound, comparing sonographers and non-sonographers. The findings indicated that the majority of participants were male (60%) and right-hand dominant (56.7%). Experience levels varied from 1 to 20 years, with 16 years being the most common (11.7%). Fascicular patterns differed between hands, with an intact pattern more common in the right hand (66.7%) and a disrupted pattern more prevalent in the left (56.7%). The median nerve shape was nearly evenly distributed in both hands; however, males were more likely to have a normal shape in the right hand (61.1%), while females more commonly exhibited a flattened shape (62.5%). Nerve mobility assessments showed normal mobility most frequently in the right hand (36.7%), whereas entrapment was more

common in the left (43.3%). A crosstab analysis between gender and sonographer status revealed a balanced distribution, with 50% of females and 41.7% of males being sonographers. No significant gender differences were observed in right-hand nerve mobility. The median nerve CSA is a critical parameter in diagnosing conditions like carpal tunnel syndrome (CTS). A study by Crasto et al. found that after a 5-minute teaching session, the rate of participants correctly identifying the median nerve increased from 36% to 97%, and their confidence in performing measurements improved from 2.4/10 to 6.5/10.[9] Comparatively, non-sonographers typically exhibit median nerve CSA values within established normative ranges, assuming the absence of occupational risk factors or systemic conditions that predispose them to nerve entrapment. However, individual factors such as age, sex, and body mass index can influence nerve size. A study by Nazer et al. established normal reference ranges for the CSA of the median nerve at the wrist and forearm using high-resolution ultrasonography in asymptomatic Pakistani adults. The study found that males had higher median nerve CSA than females, and there was a decrease in mean median nerve CSA moving from the wrist to the forearm.[10] Recent research has also examined potential diagnostic advancements. Ashworth et al. investigated the role of combining ultrasound CSA with Doppler vascularity assessment in patients with suspected CTS, finding that increased intraneural vascularity may enhance diagnostic accuracy.[11] Sevim et al. compared ultrasound with nerve conduction studies (NCS) in CTS diagnosis and found ultrasound to have comparable sensitivity (88%) and specificity (91%), making it a faster, cheaper, and more acceptable alternative. Additional studies have reinforced the value of ultrasound as a primary diagnostic tool. Kim et al. found that ultrasound not only had high sensitivity and specificity for CTS diagnosis but also detected anatomical variations and tendon abnormalities that NCS could not.[12] Similarly, Eslamian et al. demonstrated a direct correlation between wrist posture during repetitive work and increased median nerve CSA in healthcare professionals, highlighting the biomechanical impact of poor ergonomics.[13] Longitudinal studies have further emphasized the importance of occupational health monitoring. Ghasemi et al. tracked median nerve CSA changes over time in sonographers and found a progressive increase in CSA in 42% of participants, particularly those with increased workload or persistent symptoms.[14] Antonelli et al. evaluated ergonomic training programs in preventing CTS progression, showing that intervention led to stable or reduced CSA in symptomatic sonographers, whereas the control group experienced worsening symptoms.[15] In this study, the gender distribution among sonographers and non-sonographers was relatively balanced, suggesting that occupational factors rather than gender alone may contribute more significantly to variations in median nerve morphology. The observed differences in fascicular patterns and nerve shapes between hands could be attributed to hand dominance and repetitive use, aligning with findings from previous studies that have documented structural nerve changes associated with repetitive manual tasks. Future research should aim to have larger study groups and include other gold standard modalities as well.

CONCLUSION

The findings of this study highlight several key patterns in nerve characteristics among participants. A majority were male and right-hand dominant, with 16 years being the most common level of experience. Fascicular pattern analysis revealed that the right hand more frequently exhibited an intact nerve structure, while the left hand was more prone to disruption. Similarly, a flattened median nerve was observed in nearly half of the participants, with slightly higher rates in the left hand. Nerve mobility assessments showed a notable presence of nerve entrapment, particularly in the left hand, suggesting a potential side-related vulnerability. Although females tended to show a higher frequency of flattened nerves, this trend did not reach statistical significance. No meaningful association was found between gender and nerve mobility. Overall, these results suggest a greater tendency for altered nerve structure and function in the left hand, with gender differences warranting further investigation in larger studies.

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REFRENCES

1. Barlascini C, et al. Sonographic evaluation of median nerve in sonographers: The impact of working position. *Int J Occup Med Environ Health*. 2020;33(1):19-25.
2. Smith, J., Brown, A., & Carter, L. (2019). Quantitative assessment of median nerve cross-sectional area in carpal tunnel syndrome: Variability among operators. Journal of Diagnostic Ultrasound, 35(4), 215-222.
3. Johnson, K., & Lee, R. (2020). Median nerve ultrasound: Inter-operator differences in CSA measurement. Ultrasound in Medicine and Biology, 46(6), 1032-1040.
4. Williams, T., Zhang, Y., & Kumar, P. (2021). Learning curve in median nerve cross-sectional

area assessment via ultrasound. Clinical Radiology, 76(9), 711.e1-711.e8.
5. Brown, M., Allen, D., & Hughes, S. (2018). Sonographic assessment of the median nerve: Impact of operator expertise. European Journal of Radiology, 102, 45-50.
6. Davis, L., Nguyen, H., & Patel, J. (2020). Standardizing ultrasound protocols for median nerve CSA measurement: A multi-operator study. Journal of Medical Imaging and Radiation Sciences, 51(3), 364-371.
7. Taylor, R., Evans, P., & Green, J. (2017). Diagnostic accuracy of median nerve CSA measurement by trained vs. untrained operators. American Journal of Neuroradiology, 38(8), 1524-1530.
8. Robinson, F., Kim, J., & Singh, R. (2022). Comparative analysis of median nerve CSA measurements in novice and experienced operators. Ultrasound Quarterly, 38(1), 47-54.
9. Jones RE, et al. The effectiveness of ergonomic training in reducing median nerve CSA among sonographers. J Occup Rehabil. 2028;28(3):456-463.
10. Chien MY, et al. Carpal tunnel syndrome in sonographers: Prevalence, risk factors, and interventions. Work. 2020;65(3):511-517.
11. D'Addario M, et al. Diagnostic accuracy of ultrasound in carpal tunnel syndrome: Systematic review and meta-analysis. BMC Musculoskelet Disord. 2019;20(1):324.
12. Gupta A, et al. Early detection of carpal tunnel syndrome in sonographers using ultrasound: A case study. Clin Radiol. 2020;75(7):556-563.
13. Holla J, et al. The effectiveness of ergonomic interventions in preventing carpal tunnel syndrome in healthcare workers. Scand J Work Environ Health. 2019;45(6):568-574.
14. Kowalski S, et al. Impact of repetitive tasks on the development of carpal tunnel syndrome in sonographers. J Occup Health Psychol. 2021;26(2):165-172.
15. Li X, et al. Relationship between the median nerve cross-sectional area and symptoms of carpal tunnel syndrome in ultrasound professionals. Int J Occup Environ Med. 2021;12(4):179-185.